DaimlerChrysler AG

Method and apparatus for detecting the presence of a prescribed heat exchanger

The invention relates to a method for detecting the presence of a prescribed heat exchanger, in particular a catalytically active radiator in a motor vehicle, and to an apparatus for this purpose which has at least one heat exchanger, at least one measuring device, and an evaluation device.

So-called catalytically active radiators are increasingly being provided in modern motor vehicles. A catalytically active radiator for the coolant of a motor of a motor vehicle has an additional coating by means of which ozone which is present in the air which flows onto the vehicle and flows through the radiator is catalytically converted into harmless oxygen. A catalytically active radiator is sometimes also known by its trade name "PremAir radiator". Catalytically active radiators of this type have been developed particularly with regard to better environmental compatibility of the materials used and to avoid the undesired ozone, and therefore often satisfy the corresponding relevant environment regulations.

In many countries, the use of a catalytically active radiator in a motor vehicle is subject to special statutory regulations. This is because tax benefits are often granted when such radiator elements are used since these radiators have a lesser effect on the environment on account of the conversion of harmful ozone into atmospheric oxygen. However, these radiator elements are relatively expensive to buy and this often offsets the advantage of the tax saving. The expensive radiator in the motor vehicle, which results in a tax saving for example, may therefore be replaced by a comparatively low-cost radiator under certain

circumstances. It is therefore necessary to ensure that an installed catalytic radiator cannot be exchanged for a conventional radiator without a safety unit, for example the on-board diagnosis (OBD) system, being activated. These comparatively expensive radiators should therefore be protected against adulteration and manipulation.

European patent application EP 1 153 646 A1 describes a motor vehicle with a radiator having a catalytic coating, in which motor vehicle a control unit with an associated sensor system controls operation of the radiator and informs the user about the state or operation of the radiator. The sensor system also has temperature sensors at different locations in the cooling system. Said patent application does not describe securing the radiator against manipulation or a method for detecting manipulation, for example by means of temperature sensors.

Temperature-measuring devices for cooling water also have sensors which measure the absolute temperature of the cooling water after the so-called thermostat is opened, this thermostat guiding the cooling circuit past the radiator for a certain time in the closed state after the motor is started, and through the radiator after it is opened. One disadvantage of this is that the characteristics of the thermostat change over time and an absolute measurement of the cooling-water temperature is not suitable for detecting the installation of a catalytically active radiator as opposed to a conventional radiator.

The object on which the present invention is based involves providing a method and apparatus, which are as reliable as possible, for detecting the presence of a

prescribed heat exchanger, in particular a catalytically active radiator in a motor vehicle.

According to the invention, this object is achieved by a method having the features of patent claim 1 and by an apparatus having the features of patent claim 8.

Provision is accordingly made for the following:

A method for detecting the presence of a prescribed heat exchanger, in particular a catalytically active radiator in a motor vehicle, comprising the following method steps during operation of the motor vehicle:

(S1) observing a temperature of a heat-exchanger medium and at the same time observing further current operationally relevant parameters of the motor vehicle for a given time window;

(S2) detecting an expected temperature gradient over time of the temperature of the heat-exchanger medium;

(S3) detecting the current temperature gradient over time of the temperature of the heat-exchanger medium; and

(S4) detecting the presence of a prescribed heat exchanger by taking into account the expected temperature gradient and the current temperature gradient (patent claim 1).

An apparatus for detecting the presence of a prescribed heat exchanger, in particular a catalytically active radiator in a motor vehicle, comprising:

- at least one heat exchanger with a heat-exchanger medium of the motor of the motor vehicle;
- at least one measuring device for measuring the temperature of the heat-exchanger medium; and

- an evaluation device for evaluating data and for detecting the presence of a prescribed heat exchanger (patent claim 8).

Advantageous refinements and developments of the invention can be found in the subclaims and the descriptions with reference to the drawings.

The idea on which the present invention is based involves integrating a temperature sensor in a heat exchanger, which temperature sensor can be used to measure a specific absolute temperature gradient over time of the heat-exchanger medium in specific operating states of the engine. When a heat exchanger is manipulated, a different temperature gradient is measured which, with an evaluation algorithm being carried out, allows a conclusion to be drawn about the presence of a catalytically active radiator. This results in the following advantages:

The relevant statutory regulations regarding exhaust-gas standards and environmental protection can be satisfied by establishing the presence of a catalytically active radiator by means of measuring an absolute temperature gradient.

A change in the characteristics of the thermostats has no effect on the measurement result.

Manipulations can be uncovered and economic loss can be avoided.

The inventive apparatus provides further advantages:

An attempt to remove a temperature sensor from the apparatus leads to irreversible damage to the sensor.

If the temperature sensor is cut out off a catalytically active radiator which is no longer operable, or forcibly removed in some other way since it cannot be easily removed on account of the inventive apparatus, and is fitted in the engine compartment, for example to a coolant tube or to a conventional exchange radiator, this is reliably identified by the inventive method.

The illegal installation of a conventional radiator instead of a prescribed catalytically active radiator is therefore prevented.

In one preferred embodiment, method step S1 comprises the following substeps:

(S1-1) measuring values of the temperature of the heat-exchanger medium in predefined time intervals and plotting the time profile of these values; and

(S1-2) measuring values of the operationally relevant parameters at predefined time intervals and plotting the time profiles of these values.

The operating state of the motor vehicle in the time window can thus be advantageously determined.

A further refinement of the invention provides for the following the substeps in the method step S2:

(S2-1) comparing the plotted current operationally relevant parameters with predefined values;

(S2-2) determining an associated current operating state in accordance with this comparison; and

(S2-3) determining the temperature gradient expected in this current operating state.

The operating states can advantageously be determined from tables by means of stored data, it likewise being possible to determine the expected temperature gradient in a simple manner.

In one further embodiment, the current temperature gradient is detected in method step S3 by taking into account the current values of the temperature of the heat-exchanger medium plotted in the time window.

Method step (S4) advantageously comprises the following substeps:

(S4-1) comparing the current temperature gradient with the expected temperature gradient;

(S4-2) taking into account this comparison result with reference to a predefined threshold value; and

(S4-3) transmitting data signals when a prescribed heat exchanger is present.

In a further refinement of the present invention, method step S4 comprises the following substeps:

(S4-1) comparing the current temperature gradient with the expected temperature gradient;

(S4-2) taking into account this comparison result with reference to a predefined threshold value;

(S4-3) incrementing at least one counter in accordance with the comparison result from substep (S4-2);

(S4-4) carrying out method steps (S1) to (S4-3) until a predefined counter reading is reached; and

(S4-5) outputting data signals when a prescribed heat exchanger is present.

The plausibility of the measurement results can therefore be checked and said measurement results can, for example, be transmitted to a so-called on-board diagnosis system by advantageously carrying out the method more than once.

It is advantageous for another inventive embodiment to provide for the time window to be determined by a first time by at least one operationally relevant parameter reaching a predefined starting threshold value, and for

the time window to be determined by a second time by the same or at least one further operationally relevant parameter reaching the same or a further predefined ending threshold value.

In a further refinement of the invention, provision is made for the measuring device of the apparatus to have at least one temperature sensor for measuring the temperature of the heat-exchanger medium; a holding element for holding the temperature sensor; and a connection device for connection to the evaluation device.

Furthermore, it is particularly advantageous for the holding element to be connected to the heat exchanger in a non-releasable manner, as a result of which unauthorized removal is prevented in a simple manner.

Another refinement of the invention provides for the holding element for holding the temperature sensor to have a holder which corresponds to said temperature sensor.

It is particularly advantageous for the temperature sensor to have a predetermined breaking point and be connected to the holding element such that the temperature sensor is rendered permanently inoperable after said temperature sensor is removed from the holding element.

The temperature sensor is expediently a constituent part of an adapter of the connection device in this case.

It is particularly advantageous for the adapter and the holding element to have corresponding fastening elements which are designed such that they cannot be

released following assembly, since this provides an additional way of preventing manipulation.

In a further embodiment of the invention, the evaluation device has a memory device for storing values of time profiles of measured values, a data memory for storing predefined threshold values, operating state data and the like, and at least one counter.

The evaluation device is advantageously a constituent part of an on-board computer (ECU) of a motor vehicle.

The method allows a reliable conclusion to be drawn regarding the positioning of the temperature sensor and therefore whether a catalytically active radiator is present, or not, by measuring the temperature gradient in a predefined value range. In addition, the inventive apparatus provides advantageous ways of preventing manipulations.

The invention is explained in greater detail below with reference to the exemplary embodiments which are indicated in the schematic figures of the drawing, in which:

fig. 1 shows a schematic graph of profiles of operationally relevant parameters, against time, of a motor vehicle during operation;

fig. 2 shows a schematic block diagram of an exemplary embodiment of the inventive apparatus;

fig. 3 shows a schematic view of a holding element of the inventive apparatus, which holding element is installed in a radiator; and

fig. 4 shows a schematic view of a connection device of the inventive apparatus.

Unless stated otherwise, identical or functionally identical parts and/or assemblies have been provided with the same reference symbols in all of the figures of the drawing.

In fig. 1, various profiles of operationally relevant parameters of a motor vehicle are schematically illustrated against a time axis t. Reference symbol 21 denotes the vehicle speed which is illustrated with a double-thick line and at a first time t1 rises above a threshold value S in order to then run relatively constantly within a time window tf until it falls to values below the threshold value S at time t2. This constitutes, by way of example, a specific operating state of a motor vehicle, for example a relatively long motorway journey.

On account of the relatively high traveling speed, the operating temperature of the vehicle engine and therefore also the temperature of its heat-exchanger medium, for example cooling water, increase, the profile of said temperature of its heat-exchanger medium being denoted by reference symbol 22 with a solid line. This first temperature 22 of the heat-exchanger medium increases due to operation in a known manner with a dead time within the time window tf, and this can be seen from the distance to the first time t1 on the time axis t. This rise in temperature has a gradient which is relevant for the operating state and is illustrated by a straight gradient line 24 which forms a so-called temperature gradient over time.

This temperature gradient is characterized by a specific operating state of the motor vehicle. This operating state can be described in the time window tf by specific operationally relevant parameters, for example vehicle speed v in km/h, rotational speed n of

the engine in revolutions/min, exhaust-gas quantity in Δ mass/time, etc. For reasons of clarity, only the vehicle speed is shown in fig. 1.

Specific operating states can therefore be identified on the basis of the known parameter values and associated expected temperature gradients of the heat-exchanger medium can be determined. For example, it is possible to predict the expected rise in temperature of the heat-exchanger medium by means of the exhaust-gas quantity and its temperature.

This temperature gradient is also a function of where in the cooling circuit of the vehicle engine the heat-exchanger temperature is measured, in particular by where and how an associated measuring device is installed. The heat-transfer processes, which occur in the process, with different heat-transfer resistances are known and do not need to be explained.

This is illustrated by the profile of a temperature 23 of a second heat-exchanger medium, with the associated measuring device being fitted, for example, on the outside of a coolant tube. In this case, the temperature increases, after a dead time, with a second straight gradient line 25 in the same time window tf in the same operating state as in the first temperature 22 of the heat-exchanger medium. The second straight gradient line 25 can be seen as a temperature gradient with a value other than that of the first straight gradient line 24, in this case with a lower value.

The inventive method is described in the text which follows with reference to fig. 1.

At time t1, a first instance of an engine temperature exceeding 85°C, for example, is treated as an entry

criterion. If one or more specific operationally relevant parameters exceeds or exceed a predefined threshold value SW depending on a specific operating state, the time window tf is started in a first method step S1.

The operationally relevant parameters and the temperature of the heat-exchanger medium are observed within the time window tf in a subsequent method step S2, that is to say their values are measured and stored at predefined time intervals, so that the value profile is recorded, for example in a memory device of an associated evaluation unit or in the on-board computer.

After the value falls below the same or a further predefined threshold value SW or after a specific time elapses, this time being controlled, for example, by a timer which is started simultaneously at time t1, the time window tf is ended in a method step S3 at the second time t2.

In a subsequent method step S4, the observed operationally relevant parameters allow an operating state to be determined and therefore a temperature gradient which is expected in this operating state to be detected. In a further method step S6, the temperature gradient which is obtained in this way is compared with the current temperature gradient which is detected from the recorded values of the temperature of the heat-exchanger medium in a method step S5.

This comparison provides a conclusion about the location at which the values of the current temperature gradient have been measured. If the value or the value range of the current temperature gradient matches that of the expected temperature gradient, a suitable heat-exchanger, for example, is present. If the value range

of the current temperature gradient is less than or greater than that of the expected temperature gradient, the installed heat-exchanger is not suitable or a manipulated heat-exchanger system is present. The current temperature gradient can be higher, for example in a manipulated cooling system, if it is heated in a manipulative manner in order to obtain higher temperature gradients. However, the other criteria cannot be maintained in this case, as a result of which detection is nevertheless possible.

In order to check the plausibility of these detection values, this method is repeated more than once in a further inventive embodiment, with a counter being incremented for each detected comparison value up to a predefined value with each run through the method.

The result of the detection is transmitted to the on-board computer for further processing or indication purposes, for example by means of a data bus inside the vehicle. Special indicators or measures can be initiated when a manipulation has occurred.

Fig. 2 shows a schematic block diagram of an exemplary embodiment of the inventive apparatus for carrying out the inventive method.

The apparatus 1 comprises an evaluation unit 13 to which a measuring device 5 for measuring the temperature of a heat-exchanger medium in a heat exchanger 2 is connected by means of a connection device 8 and a line 12.

Further detection units 17, 18, 19, 20 for operationally relevant parameters, for example rotational speed 17 of the engine, engine temperature 18, exhaust-gas quantity 19, vehicle speed 20, are

connected to the evaluation unit 13. The detection units 17, 18, 19, 20 and the like can also be connected to an on-board computer 14' which is connected to the evaluation unit 13 by means of a data-transmission means 26 and therefore supplies the required data values.

The evaluation unit 13 has at least one memory device 15 and at least one counter 16. It may also be provided with a timer (not illustrated).

The memory device 16 is used, inter alia, to store recorded measured values; the counter 16 is an event counter.

The evaluation device 13 also has a data memory 27 which contains predefined table values, threshold values and the like which are used to determine the operating states and expected values.

The evaluation unit 13 may be a constituent part of an on-board computer 14 which is symbolized by a double dot-and-dash line.

The measuring device 5 has a holding element 6 with a holder 7 for holding a temperature sensor 10, as illustrated in figure 3. The holding element 6 is designed such that it is installed in the heat exchanger 2, for example in an intermediate space 4 between lamellae 3. The holding element 6 is preferably stuck in in such a way that it damages the heat exchanger 2 when an attempt is made to remove it. Other fastening options are also feasible.

The temperature sensor 10 is located in an adapter 9 of the connection device 8, as shown in fig. 4. The

temperature sensor 10 and the holder 7 of the holding element 6 are of corresponding shape and dimensions.

The adapter 9 is equipped with fastening elements 11, for example flexible retaining fingers with barbed hooks, which, together with corresponding fastening elements (not illustrated) on the holding element 6, form a connection which cannot be released following assembly. Improper removal is therefore effectively prevented.

In addition, in one embodiment, the temperature sensor 10 is adhesively bonded in the holder 7 of the holding element 6 such that it is rendered inoperable when an attempt is made to remove it, for example by means of a predetermined breaking point.

Although the present invention has been described with reference to preferred exemplary embodiments above, it is not restricted to these but can be modified in a variety of ways.

For example, it is feasible for the memory device 15, the counter 16 and a timer to be constituent parts of the on-board computer.

It is also feasible for the inventive method to be used for the advance detection of functional faults in heat-exchanger systems.

The data memory 27 may also have wireless connecting devices to external data memories, for example via satellite connection. It may also be a CD-ROM or DVD device.